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Seaweed Supplementation in Dairy Cattle: Implications for Methane Mitigation, Milk Yield and Nutritional Quality

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Abstract

The integration of seaweed into dairy cow diets has garnered increasing attention due to it's dual potential to mitigate enteric methane emissions and improve milk production and quality. Seaweeds, classified broadly into brown, red, and green macroalgae, possess distinct biochemical profiles rich in polysaccharides, minerals, antioxidants, and secondary metabolites. Notably, brown seaweeds like *Ascophyllum nodosum* and *Sargassum wightii* have demonstrated promising effects in enhancing milk composition and reducing methane emissions. Despite variability in outcomes depending on species, dosage, and cattle breed, consistent improvements in milk iodine levels and rumen fermentation parameters have been observed. This article reviews recent findings on seaweed's influence on dairy performance, methane mitigation, and nutritional enhancements, underscoring its potential as a functional and environmentally sustainable feed additive.

Keywords: Seaweed, methane mitigation, dairy cattle, milk

Introduction

Seaweeds, or marine macroalgae, are a heterogeneous group of photosynthetic organisms categorized into three major classes: brown algae (Phaeophyceae), red algae (Rhodophyceae), and green algae (Chlorophyceae). Each class encompasses species with distinct biochemical compositions that impact their nutritional and functional utility in livestock nutrition.

Red Seaweed

Green seaweed

Brown seaweed

Brown seaweeds—such as *Ascophyllum nodosum*, *Sargassum wightii*, *Laminaria digitata*, *Macrocystis pyrifera*, and *Asparagopsis taxiformis*—are particularly valued for their rich content of complex polysaccharides (e.g., alginate, fucoidan), iodine, phlorotannins, and antioxidants. These bioactive compounds contribute to improved immunity and methane mitigation. Red seaweeds like *Kappaphycus alvarezii* and *Gracilaria* are known for their high carrageenan content and exhibit prebiotic and immunomodulatory effects. Green seaweeds such as *Ulva lactuca*, though less explored in ruminant nutrition, are nutrient-rich and have potential due to their protein and mineral content.

The growing focus on sustainable dairy production has spurred interest in seaweed as a natural feed additive. Seaweeds provide essential nutrients and can enhance the nutritional profile of milk, especially its mineral content. Additionally, seaweed supplementation is being explored for its capacity to mitigate

methane emissions, a major environmental concern in ruminant livestock.

Methane Mitigation through Seaweed Supplementation

Wang et al. (2008) reported that phlorotannin from the seaweed *Ascophyllum nodosum* significantly reduced methane and total gas production. The anti-methanogenic activity of seaweeds is primarily attributed to their richness in phenolic compounds—especially phlorotannins found in brown seaweeds—and other plant secondary metabolites (Kinley and Fredeen, 2015). Phlorotannins bind with proteins and carbohydrates, reducing their degradability in the rumen and leading to a decrease in microbial fermentation and methane output.

Munde (2018) found that feeding red seaweed to crossbred cattle calves reduced methane emissions by 26% and 18% for *Gracilaria* and *Kappaphycus*, respectively, compared to control. Other studies also confirm that seaweed supplementation significantly decreases in vitro methane production (Maia et al., 2016; Handique, 2022). The presence of halogenated low molecular weight compounds—mainly brominated and chlorinated haloforms—in seaweeds inhibits methyl transfer reactions essential for methanogenesis (Liu et al., 2011).

These findings highlight the role of seaweeds as promising natural additives for reducing ruminant methane emissions without relying on synthetic compounds.

Effect on Milk Production

The impact of seaweed supplementation on milk yield has been inconsistent across studies. Sharma et al. (2022) reported no significant changes in milk yield with *Kappaphycus alvarezii* supplementation in crossbred cows, while similar null results were observed by Cermak et al. (2011) and Karatzia et al. (2012) with *Ascophyllum nodosum*.

In contrast, Singh et al. (2015) observed increased milk yield and fat-corrected milk in Sahiwal cows fed 20% *Sargassum wightii*. Desai and Shukla (1975) also noted no negative effects when *Sargassum* was included up to 30% in concentrate mixtures for Kankrej cows. Positive responses were also observed by Lee et al. (2005) and Bendary et al. (2013) with brown seaweed supplementation.

However, Stefenoni et al. (2021) reported a decrease in milk and milk fat yield in cows fed 0.5% *Asparagopsis taxiformis*, emphasizing the importance of dosage and seaweed species.

Effect on Milk Composition and Quality

Though changes in milk yield are mixed, improvements in milk composition—especially mineral enrichment—are more consistent. Hong et al. (2015) and Antaya et al. (2019) reported no changes in basic milk constituents (fat, protein, lactose) with brown seaweed supplementation. However, Xue et al. (2019) observed a significant increase in iodine levels with 5% kelp powder inclusion.

Similarly, Newton et al. (2021) found a 200.8% increase in iodine and a 36.7% increase in arsenic when cows were fed *Ascophyllum nodosum* and *Laminaria digitata*. Stefenoni et al. (2021) also documented elevated iodine and bromide concentrations with *Asparagopsis*.

Singh et al. (2014) found higher calcium levels in milk of cows fed 20% *Sargassum wightii*, while Caroprese et al. (2016) reported improved omega-3 fatty acid profiles and lower atherogenic indices in milk from sheep fed *Ascophyllum nodosum* with flaxseed.

Discussion

The outcomes of seaweed supplementation in dairy cattle are influenced by multiple factors: seaweed species, chemical composition, inclusion rate, cattle breed, and feeding duration. Brown seaweeds, particularly *Sargassum wightii* and *Macrocystis pyrifera*, consistently improve milk yield and composition, whereas *Ascophyllum nodosum* is more impactful in altering mineral content.

The elevation of milk iodine and essential fatty acids through seaweed feeding suggests functional benefits for human health. However, concerns about excessive mineral accumulation (e.g., arsenic, bromide) call for regulatory monitoring and species-specific guidelines.

Conclusion

Seaweed supplementation, especially with brown macroalgae, presents a promising strategy for enhancing dairy cattle productivity and reducing environmental impact. While its influence on milk yield is variable, the positive effects on milk mineral content—particularly iodine—and methane mitigation make seaweed a functional and sustainable feed additive. Nevertheless, species selection, dosage optimization, and safety evaluations are essential for integrating seaweeds effectively into dairy nutrition. Further research should focus on long-term impacts, economic feasibility, and standardized feeding protocols to maximize the benefits of seaweed in ruminant production systems.

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